

## CLAIMS

What is claimed is:

1     1.     A method for fabricating a thermal management system for a micro-  
2     component device, comprising:  
3         overlaying a target substrate with a blank in sheet form;  
4         stamping a microchannel structure having a plurality of outer walls  
5     enclosing a predefined area from the blank;  
6         bonding the microchannel structure to a heat dissipating side opposite from a  
7     micro-component device facing side of a first substrate, the micro-component  
8     device facing side adapted to thermally engage with the micro-component device;  
9         bonding the microchannel structure to a second substrate opposite the first  
10    substrate, defining a closed volume microchannel; and  
11         substantially filling the microchannel with a fluid thermal interface material.

1     2.     The method of claim 1, wherein stamping a microchannel structure having a  
2     plurality of outer walls enclosing a predefined area from the blank, comprises:  
3         providing a press tool having a predetermined relief structure with cutting  
4     blades adapted to cut the blank;  
5         pressing the press tool into the blank such that the cutting blades cut through  
6     to the target substrate, cutting the blank into a microchannel structure and waste  
7     portions, the microchannel structure comprising a plurality of outer walls defining  
8     an edge seal enclosing a predetermined area of the target substrate; and  
9         removing the waste portions.

1     3.     The method of claim 2, wherein providing a press tool having a  
2     predetermined relief structure with cutting blades adapted to cut the blank  
3     comprises:  
4         providing a press tool having a predetermined relief structure with cutting  
5     blades adapted to cut the blank, the relief structure having an inner surface between  
6     adjacent cutting blades; and

7            wherein pressing the press tool into the blank such that the cutting blades cut  
8 through to the target substrate, cutting the blank into a microchannel structure and  
9 waste portions, comprises:

10           pressing the press tool into the blank such that the cutting blades cut through  
11 to the target substrate cutting the blank into a microchannel structure and waste  
12 portions, the inner surface applying a predetermined compressive force onto the  
13 microchannel structure to facilitate a fluid-tight diffusion bond between the  
14 microchannel structure and the target substrate.

1    4.       The method of claim 1, wherein bonding the microchannel structure to a first  
2 substrate comprises:

3           bonding the microchannel structure to the target substrate, wherein the target  
4 and first substrates are one and the same.

1    5.       The method of claim 4, wherein bonding the microchannel structure to a first  
2 substrate comprises:

3           applying a compressive force between the first substrate and the  
4 microchannel structure to effect a fluid-tight diffusion bond between the first  
5 substrate and the microchannel structure.

1    6.       The method of claim 5, wherein applying a compressive force between the  
2 target substrate and the microchannel structure to effect a fluid-tight diffusion bond  
3 between the target substrate and the microchannel structure comprises:

4           applying a compressive force at an elevated temperature below the melt  
5 temperature of either the target substrate and the microchannel structure over a  
6 predetermined period of time to effect a fluid-tight diffusion bond between the  
7 target substrate and the microchannel structure.

1    7.       The method of claim 1, wherein bonding the microchannel structure to a  
2 second substrate opposite the first substrate, defining a closed volume microchannel  
3 comprises:

4        providing a second substrate onto the microchannel structure opposite the  
5        target substrate; and  
6        applying a predetermined compressive force to the second substrate and  
7        microchannel structure sufficient to provide a fluid-tight diffusion bond there  
8        between.

1        8.        The method of claim 7, wherein applying a predetermined compressive force  
2        to the second substrate and microchannel structure sufficient to provide a fluid-tight  
3        bond there between comprises:

4               applying a predetermined compressive force at an elevated temperature  
5        below the melt temperature of either the target substrate, second substrate, and the  
6        microchannel structure, over a predetermined period of time to effect a fluid-tight  
7        diffusion bond between the second substrate and the microchannel structure.

1        9.        The method of claim 1, wherein substantially filling the microchannel with a  
2        fluid thermal interface material comprises:  
3               substantially filling the microchannel with an indium alloy that is liquid at a  
4        predetermined micro-component device operating temperature.

1        10.        The method of claim 1, further comprising thermally coupling the micro-  
2        component device facing side of the first substrate with a heat-producing side of the  
3        micro-component device.

1        11.        The method of claim 10, wherein thermally coupling the micro-component  
2        device facing side of the first substrate with a heat-producing side of the micro-  
3        component device comprises:

4               thermally coupling the micro-component device facing side of the first  
5        substrate with a backside of a microelectronic die, the microelectronic die  
6        comprising integrated circuits.

1        12.        The method of claim 11, further comprising:

2 thermally coupling the fluid thermal interconnect material with one or more  
3 thermal dissipation devices selected from the group consisting of heat pipe, thermal  
4 dissipation fins, fan, heat exchanger, and flat plate.

1 13. A micro-component device package, comprising:

2 a micro-component device comprising a die and a carrier substrate, the die  
3 having a backside, the die being electrically interconnected with the carrier  
4 substrate; and

5 a thermal management system in thermal engagement with the backside, the  
6 thermal management system comprising:

7 a first substrate having a die facing side and an opposite heat  
8 dissipation side, the die facing side thermally coupled to the back side of the  
9 die;

10 a microchannel structure having a plurality of outer walls enclosing a  
11 predefined area, the microchannel structure coupled to the heat dissipation  
12 side of the first substrate;

13 a second substrate, the second substrate coupled to the microchannel  
14 structure, the first substrate, microchannel structure and the second substrate  
15 defining a closed volume microchannel; and

16 a thermal interface material disposed within the closed volume  
17 microchannel.

1 ~~14~~ 14. The micro-component device package of claim 13, wherein the first  
2 substrate includes an integrated heat spreader and the second substrate includes a  
3 heat sink.

1 15. The micro-component device package of claim 13, wherein the thermal  
2 management system further comprises:

3 an inlet aperture through the outer wall in fluid communication with the  
4 microchannel; and

5 a vent aperture through the second substrate or the outer wall, the vent  
6 aperture in fluid communication with the microchannel.

1 16. The micro-component device package of claim 15, wherein the vent aperture  
2 includes a semi permeable membrane plug adapted to allow the passage of gas but  
3 not the fluid thermal interface material.

1 17. The micro-component device package of claim 15, wherein the thermal  
2 management system further comprises:  
3 a thermal interface material supply line coupled to the inlet aperture;  
4 a thermal interface material discharge line coupled to the vent aperture; and  
5 a micropump coupled to the supply line and the discharge line, the  
6 micropump configured to provide a pressure differential to circulate the fluid  
7 thermal interface material from the supply line, through the microchannel, and to the  
8 discharge line.

1 18. The micro-component device package of claim 17, wherein the thermal  
2 management system further comprises a heat exchanger in fluid communication  
3 with the microchannel, the heat exchanger adapted to dissipate thermal energy from  
4 the fluid thermal interface material.

1 19. The micro-component device package of claim 13, wherein the thermal  
2 interface material is selected from a group including indium alloy, Ga-In-Sn Alloy,  
3 Cesium Francium, and Rubidium.

1 20. The micro-component device package of claim 13, wherein the micro  
2 component device is an integrated circuit.

1 21. A system comprising:  
2 a selected one of a digital signal processor and a graphics processor; and  
3 a micro-component device package coupled to the selected one of a digital  
4 signal processor and a graphics processor, including  
5 a micro-component device comprising a die and a carrier substrate, the  
6 die having a backside, the die being electrically interconnected with  
7 the carrier substrate; and  
8 a thermal management system in thermal engagement with the backside,  
9 the thermal management system comprising:  
10 a first substrate having a die facing side and an opposite heat  
11 dissipation side, the die facing side thermally coupled to the  
12 back side of the die;  
13 a microchannel structure having a plurality of outer walls  
14 enclosing a predefined area, the microchannel structure  
15 coupled to the heat dissipation side of the first substrate;  
16 a second substrate, the second substrate coupled to the  
17 microchannel structure, the first substrate, microchannel  
18 structure and the second substrate defining a closed volume  
19 microchannel; and  
20 a thermal interface material disposed within the closed volume  
21 microchannel.

1 22. The system of claim 21, wherein the first substrate of the thermal  
2 management system of the micro-component device package includes an integrated  
3 heat spreader and the second substrate includes a heat sink.

1 23. The system of claim 21, wherein the thermal management system further  
2 comprises:  
3 an inlet aperture through the outer wall in fluid communication with the  
4 microchannel; and

5           a vent aperture through the second substrate or the outer wall, the vent  
6   aperture in fluid communication with the microchannel.

1   24.    The system of claim 23, wherein the vent aperture includes a semi  
2   permeable membrane plug adapted to allow the passage of gas but not the fluid  
3   thermal interface material.

1   25.    The system of claim 23, wherein the thermal management system further  
2   comprises:  
3           a thermal interface material supply line coupled to the inlet aperture;  
4           a thermal interface material discharge line coupled to the vent aperture; and  
5           a micropump coupled to the supply line and the discharge line, the  
6   micropump configured to provide a pressure differential to circulate the fluid  
7   thermal interface material from the supply line, through the microchannel, and to the  
8   discharge line.

1   26.    The system of claim 25, wherein the thermal management system further  
2   comprises a heat exchanger in fluid communication with the microchannel, the heat  
3   exchanger adapted to dissipate thermal energy from the fluid thermal interface  
4   material.

1   27.    The system of claim 21, wherein the thermal interface material is selected  
2   from a group including indium alloy, Ga-In-Sn Alloy, Cesium Francium, and  
3   Rubidium.